



NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

April 12, 2000

Fire Fighter Dies After Extinguishing a Fire in a Two-Story Dwelling - Pennsylvania

SUMMARY

On July 29, 1999, a 49-year-old male Fire Fighter responded to a fire in a two-story dwelling. After extinguishing the fire and taking a short break, the victim had a witnessed collapse. After approximately 56 minutes of cardiopulmonary resuscitation (CPR) and advanced life support (ALS) on scene and at the hospital, the victim died. The death certificate and the autopsy, both completed by the City Medical Examiner, listed "arteriosclerotic cardiovascular disease" as the immediate cause of death and "heat stress" as a significant condition. Pertinent autopsy results included severe coronary artery disease and extensive subendocardial scarring of the left ventricle (consistent with remote [old] heart attacks).

Other agencies have proposed a three-pronged strategy for reducing the risk of on-duty heart attacks and cardiac arrests among fire fighters. This strategy consists of (1) minimizing physical stress on fire fighters, (2) screening to identify and subsequently rehabilitate individuals at higher risk and (3) encouraging increased individual physical capacity. The following issues are relevant to this fire department:

- *Fire fighters should have annual medical evaluations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.*
- *Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by phasing in a mandatory wellness/fitness program for fire fighters.*

- *Carboxyhemoglobin levels should be tested on symptomatic or unresponsive fire fighters exposed to smoke.*

INTRODUCTION & METHODS

On July 29, 1999, a 49-year-old male Fire Fighter lost consciousness after extinguishing a fire in a two-story dwelling. Despite CPR and ALS administered by crew members, fire department paramedics, and emergency room personnel, the victim died. NIOSH was notified of this fatality on August 2, 1999, by the United States Fire Administration. On September 8, 1999, NIOSH contacted the affected Fire Department to initiate the investigation. On September 21, 1999, a Safety and Occupational Health Specialist and an Epidemiologist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Pennsylvania to conduct an on-site investigation of the incident.

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty.

Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at:

<http://www.cdc.gov/niosh/firehome.html>

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Fatality Assessment and Control Evaluation Investigative Report #99F-50

Fire Fighter Dies After Extinguishing a Fire in a Two-Story Dwelling - Pennsylvania

During the investigation NIOSH personnel met with the

- Deputy Fire Commissioner for Technical Services
- Fire Marshal
- Fire Department Personnel Director
- Fire Department Physician
- Crew members involved in this incident
- Fire Department paramedics involved in this incident
- Victim's spouse

During the site visit NIOSH personnel reviewed the following:

- Existing Fire Department investigative records, including the Department's fire fighter fatality investigation report, incident reports, coworker statements, and dispatch records
- The victim's personnel record maintained at the Fire Department
- Emergency medical services-ambulance report
- The hospital's records of the resuscitation effort
- Autopsy results and death certificate
- Past medical records of the deceased
- Fire Department policies and operating procedures
- Fire Department training records
- The Fire Department annual report for 1998

NIOSH personnel also notified the Fire Commissioner and the IAFF Local President regarding the NIOSH visit and visited the area where the structure fire occurred.

INVESTIGATIVE RESULTS

Incident Response. On July 29, 1999, at 2037 hours, Engine 28, Engine 7, Ladder 10, Ladder 16, and Battalion 10 were dispatched on a tactical box alarm to a fire in a two-story dwelling. The structure involved was an occupied, two-story, brick, middle-

of-a-row-type dwelling measuring 15 by 35 feet. The building was of ordinary construction. At the time of dispatch, the temperature was 86°F and relative humidity was 47%.

Battalion 10 (Battalion Chief and an Aide), Engine 28 (Captain and three Fire Fighters [including the victim]), Engine 7 (Acting Lieutenant and three Fire Fighters), Ladder 10 (Lieutenant and four Fire Fighters), and Ladder 16 (Lieutenant and four Fire Fighters) responded at 2038 hours.

Engine 28 arrived on scene at 2040 hours, pulled in front of the fire building, and connected to a hydrant. The Captain radioed Dispatch that there was fire on the second floor in the front and that the first Engine and Ladder would go into service. The Driver/Operator stretched a 1¾-inch hoseline to the front of the structure. The Captain, wearing full bunker gear and self-contained breathing apparatus (SCBA), entered the structure to search for occupants. There was heavy smoke on the first and second floors and extreme heat on the second floor. The fire in the second-floor, front bedroom was rolling. The front bedroom door was partially closed, but the upper half was burned through.

Ladder 10 arrived on scene. The victim and an Engine 28 crew member, wearing full bunker gear and SCBA, stretched the 1¾-inch hoseline to the second floor via the interior stairway.

Engine 7 arrived on scene and was placed in standby. Battalion 10 arrived on scene at 2041 hours, and Ladder 16 arrived shortly thereafter. The Engine 28 crew (including the victim) located the fire in the front bedroom and began to extinguish it. Ladder 10 and Ladder 16 crew members performed ventilation and continued to search for occupants.

At 2043 hours, Battalion 10 notified Dispatch that all occupants were out of the structure. At 2046



Fatality Assessment and Control Evaluation Investigative Report #99F-50

Fire Fighter Dies After Extinguishing a Fire in a Two-Story Dwelling - Pennsylvania

hours, Battalion 10 notified Dispatch that the bulk of the fire was knocked down and that one Engine and both Ladders were in service at that time. At 2047 hours, Battalion 10 placed the fire under control and called for Engine 7 to make themselves available.

There was a lot of steam present in the room after the fire was knocked down. Once the fire had been placed under control, the victim proceeded outside the dwelling to take a break. He removed his SCBA and sat down on the rear step of Engine 28. He refused a drink of water offered by the Driver/Operator of Engine 28 and returned to the house to assist in overhauling operations.

After the victim reentered the house, his Engine 28 crew member on the hose line asked the victim how he was doing. The victim related that he was OK. Ladder 10 crew members completed overhaul (checking for fire spread) in the fire room.

At 2058 hours, Ladder 16 became available and left the scene. The Engine 28 Captain ordered the room to be wet down. The Engine 28 crew member wet down half of the room then asked the victim to move to the other side of the room so the wet down could be completed. Just after the victim moved to the other side of the room, he suddenly collapsed onto the bed frame. The Engine 28 crew member tried to arouse the victim, but he did not respond. The victim made snoring noises. The crew member yelled out the window that a man was down. The Engine 28 Captain ordered that the semi-automatic external defibrillator (SAED) and the medical bag be taken to the victim. The Engine 28 Driver/Operator retrieved the equipment, and he and the Captain went to the victim's location. Crew members removed the victim from the bed, laid him on the floor, and removed his bunker coat. The victim was unresponsive, not breathing, and pulseless.

A medic unit was requested at 2104 hours and Medic 8 (two Paramedics) responded immediately. Fire fighters inserted an oral airway into the victim's airway and began CPR (chest compressions and assisted ventilation with a bag-valve-mask and 100% oxygen) and hooked up the SAED. A ventricular fibrillation (V. Fib.) was revealed. Medic 8 arrived on scene at 2108 hours.

A heart monitor was also attached to the victim and revealed V. Fib. However, due to the very wet conditions in the fire room, no attempt was made to defibrillate (per standard operating procedure). The victim was intubated, placed onto a stretcher, removed from the building, and loaded into the medic unit. Once inside the squad, the remainder of the victim's gear was removed. Medic 8 departed the scene at 2120 hours en route to the hospital. One Fire Fighter from Ladder 10 drove Medic 8 while the two Paramedics performed advanced life support (ALS) measures and two Fire Fighters from Ladder 10 continued CPR. Intravenous (IV) access was established, and intravenous normal saline solution and medications were administered consistent with ALS protocols. Monitor electrodes on the victim were replaced due to the victim's wet skin. His heart rhythm continued in V. Fib.

Medic 8 arrived at the hospital at 2122 hours. Upon arrival at the hospital, the victim's heart rhythm was reevaluated and found again to be in V. Fib. One shock was delivered in the ambulance; the victim was then removed from Medic 8 and taken into the emergency room (ER). CPR and ALS procedures were performed for a total of 17 minutes on scene and for 2 minutes during transport to the hospital. In the ER, full ALS protocols were followed. At 2142 hours the victim was pronounced dead and resuscitation efforts were stopped.



Fatality Assessment and Control Evaluation Investigative Report #99F-50

Fire Fighter Dies After Extinguishing a Fire in a Two-Story Dwelling - Pennsylvania

Medical Findings. The death certificate was completed by the City Medical Examiner, who listed “atherosclerotic cardiovascular disease” as the immediate cause of death and “heat stress” as a significant condition. The victim had three risk factors for coronary artery disease: history of smoking, high cholesterol, and obesity. He did not report ever having chest pain or any other symptom suggestive of angina to his spouse, peers, personal physician, or Fire Department physician. Although this victim routinely saw a personal physician, there was no indication from these visits that an ECG had been conducted or that there was any personal medical reason to do so.

Pertinent findings from the autopsy, performed by the Medical Examiner on July 30, 1999, are listed below:

- Coronary artery disease
 - Proximal and middle left anterior descending branch: near complete occlusion
 - Proximal right coronary artery: 80% stenosis
 - Proximal left circumflex branch: up to 60% stenosis
- Extensive subendocardial scarring of the left ventricle (consistent with prior MIs)
- No evidence of smoke inhalation (no soot in nose or mouth or airways)

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department was comprised of 2,432 uniformed personnel and served a population of 1,480,000 residents in a geographic area of 130 square miles. The Fire Department has 60 fire stations where fire fighters work the following tour of duty: Day 1, 0800-1800; Day 2, 0800-1800; Day 3, 1800-0800; Day

4, 1800-0800; off duty for 4 days. There are 4 platoons. Each shift of an engine company is staffed with an officer and three fire fighters; each ladder company, an officer and four fire fighters. The emergency medical service is a component of the Fire Department.

In 1998 the Department responded to 220,565 total calls: 163,208 total medical incidents and 57,357 total fire and emergency service incidents (36,456 other responses [police assist, medical assist, citizen assist, malfunctioning equipment], 9,890 nonstructure fires, 8,151 false alarms, and 2,860 structure fires). Total calls included 22 multiple-alarm fires.

The day of the incident, the victim began his shift at 1800 hours. The beginning of the shift was spent checking out the equipment and helping other crew members prepare dinner; during this time the victim did not report or show signs of discomfort, pain, or distress. The incident described was the victim's first emergency response during his shift.

Training. The Fire Department provides all new fire fighters with the basic 15-week recruit training, conducted at the city's Fire Academy, to become certified Fire Fighters. All fire fighters are semi-automatic external defibrillator (SAED)- and Emergency Medical Technician (EMT)- certified. The victim was a certified Fire Fighter/EMT and had 10 years of fire fighting experience.

Preemployment/Preplacement Evaluations. The Department requires (1) a preemployment/preplacement medical evaluation for all new hires, (2) a physical examination when a fire fighter is promoted, and (3) a physical examination when a fire fighter is off duty for illness/injury for more than 14 days. Components of the preemployment/preplacement evaluation for all applicants include the following:

Fire Fighter Dies After Extinguishing a Fire in a Two-Story Dwelling - Pennsylvania

- A complete medical history
- Height, weight, and vital signs
- Physical examination
- Vision test
- Hearing test
- Complete blood count (CBC)
- Cholesterol and triglycerides
- Urinalysis
- Urine drug test
- Pulmonary function tests (lung tests)
- Resting Electrocardiogram
- Exercise stress test (EST)
- Chest X-ray

These evaluations are performed by the Office of the City Medical Director, who makes a decision regarding medical clearance for fire fighting duties. New hires are also required to complete a physical capacity test at the city Fire Academy. This is a non-timed performance evaluation of typical fire fighting duties.

Periodic Evaluations. No routine annual/periodic medical evaluations are required by this Department for **all** fire fighters. An employee who is injured at work must be cleared for “return to work” by a physician in a Workman’s Compensation Clinic. An employee who is ill and away from work for 7 or more days must be cleared for “return to work” by the City Medical Director. Those fire fighters assigned to the hazardous materials unit have medical evaluations every 2 years. The contents of these evaluations are the same as the preemployment/preplacement evaluation. The Department does not require annual/periodic physical capacity tests. Some fire stations have exercise (strength and aerobic) equipment, typically purchased by the fire fighters themselves. The Department has voluntary smoking cessation and weight control programs but no required fitness/wellness program and no specific required medical clearance for SCBA use.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.¹ Risk factors for its development include family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes.² The victim had three of the risk factors for coronary artery disease: hypertension, high cholesterol, and history of smoking. On autopsy, he had moderate to severe atherosclerotic disease in his coronary arteries.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.³ However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.⁴ Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.⁵ This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques.

Fire fighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.⁶⁻⁸ Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.⁹⁻¹² The mental and physical stress of responding to the emergency, climbing the stairs to the second floor in his bunker gear and SCBA, entering a very hot, smoke-filled building, the high atmospheric temperature and humidity, along with his previously undiagnosed underlying atherosclerotic coronary artery disease, all probably contributed to this victim’s heart attack, cardiac arrest, and sudden death. This victim did not report prior episodes of angina (heart pain) during physical activity performed

Fire Fighter Dies After Extinguishing a Fire in a Two-Story Dwelling - Pennsylvania

on or off the job. However, sudden cardiac arrest is often the first overt manifestation of ischemic heart disease.¹³

Seventeen minutes elapsed from the time the victim's heart rhythm was first found to be in V. Fib. (in the fire room at approximately 2105 hours) until the first shock was administered in the hospital's parking lot (approximately 2122 hours). While this rhythm can be converted by electrocardioversion (defibrillation), no shock was administered in the fire room by the SAED or the medic's heart monitor due to the extremely wet environment potentially endangering EMS personnel.¹⁴⁻¹⁵ This action represents prudent judgment by the EMS personnel. Carrying the victim to a drier environment and drying him off before departing for the hospital, thereby allowing shocks to be delivered without putting themselves in danger, would have been appropriate. However, it is unknown whether this was considered at the time, or whether, given the circumstances at the scene (including the short distance to the hospital), it was feasible.

Discrepancies existed between the frequency and content of the Department's medical evaluation and those recommended by the NFPA.¹⁶ For example, the Department conducted extensive preemployment/preplacement medical evaluations, including EST on all applicants, regardless of age. The NFPA recommends EST for those 35 years old and above with known CAD risk factors and for those 40 years old and above without CAD risk factors, and that the tests should be conducted at least every 2 years.

The NFPA also recommends annual medical evaluations with periodic medical examinations. Stress tests are included as part of these medical examinations. If a treadmill test had been performed on this Fire Fighter in the 2 years before his death, his underlying CAD would likely have been identified,

and he could have been directed toward further evaluation and treatment.¹⁷

RECOMMENDATIONS AND DISCUSSION

The following recommendations address health and safety generally. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac death among fire fighters. These recommendations have not been evaluated by NIOSH, but represent research presented in the literature or of consensus votes of Technical Committees of the National Fire Protection Association or labor/management groups within the fire service.

Recommendation #1: Fire fighters should have annual medical evaluations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content and scheduling of periodic medical evaluations for fire fighters can be found in *NFPA 1582, Standard on Medical Requirements for Fire Fighters*,¹⁶ and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs wellness/fitness initiative.¹⁸ Although the Department is not legally required to follow any of these standards, we recommend the City and Union **negotiate** the content and frequency to be consistent with the above guidelines. Specifically, the preemployment/preplacement stress (EKG) tests are not medically necessary for applicants under the age of 35. Additionally, the use of chest X-rays in surveillance activities in the absence of significant exposures, symptoms, or medical findings has not been shown to reduce respiratory or other health impairments.¹⁶ Therefore, only preemployment/preplacement chest



Fatality Assessment and Control Evaluation Investigative Report #99F-50

Fire Fighter Dies After Extinguishing a Fire in a Two-Story Dwelling - Pennsylvania

X-rays are recommended by the NFPA. Unnecessary X-ray studies result in unnecessary exposure to radiation and represent an unnecessary expense for the Department. On the other hand, annual/periodic medical evaluations should be conducted, and according to the NFPA, should include EST, beginning at age 35 for fire fighters with risk factors for CAD. In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire fighting tasks. Applying NFPA 1582 involves legal issues, so it should be carried out in a **confidential, nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for Fire Department Administrators regarding legal considerations in applying the standard.

Applying NFPA 1582 also involves economic issues. These economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs of dealing with the medical evaluation results. *NFPA 1500, Standard on Fire Department Occupational Safety and Health Program*, addresses these issues in Chapter 8-7.1 and 8-7.2.¹⁹

The success of medical programs hinges on protecting the affected fire fighter. The department must (1) keep the medical records confidential, (2) provide alternate duty positions for fire fighters in rehabilitation programs, and (3) if the fire fighter is not medically qualified to return to active fire fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives.

Recommendation #2: Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by phasing in a mandatory wellness/fitness program for fire fighters.

NFPA 1500 requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.¹⁹ In 1997, the International Association of Fire Fighters and the International Association of Fire Chiefs joined in a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual with a video detailing elements of such a program.¹⁸ The Fire Department and the Union should review these materials to identify applicable elements for their department. Other large-city negotiated programs can also be reviewed as potential models. By all reports, this particular fire fighter was very aerobically and physically fit. The city had voluntary smoking cessation and weight control programs; however, no mandatory wellness/fitness program was in place.

Recommendation #3: Carboxyhemoglobin levels should be tested on symptomatic or unresponsive fire fighters exposed to smoke.

Unfortunately, a carboxyhemoglobin level was not done at the hospital; this would have provided a good assessment of the victim's exposure to carbon monoxide. It is unlikely, however, that his carboxyhemoglobin level would have been elevated given the victim's estimated time of smoke exposure. Furthermore, knowledge of his carboxyhemoglobin level would not have affected his treatment or outcome since he was already receiving oxygen and was pronounced dead shortly after arrival at the hospital. Nonetheless, to assist the investigation of fire-related deaths, we recommend performing carboxyhemoglobin levels to rule out carbon monoxide poisoning.

Fire Fighter Dies After Extinguishing a Fire in a Two-Story Dwelling - Pennsylvania

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Fatality Assessment and Control Evaluation
Investigative Report #99F-50

Fire Fighter Dies After Extinguishing a Fire in a Two-Story Dwelling - Pennsylvania

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